GE Power & Water

Wind Turbine Layout & Performance Optimization

A manufacturer's perspective

NREL Wind Energy Systems Engineering Workshop

Wind Plant Design and Optimization

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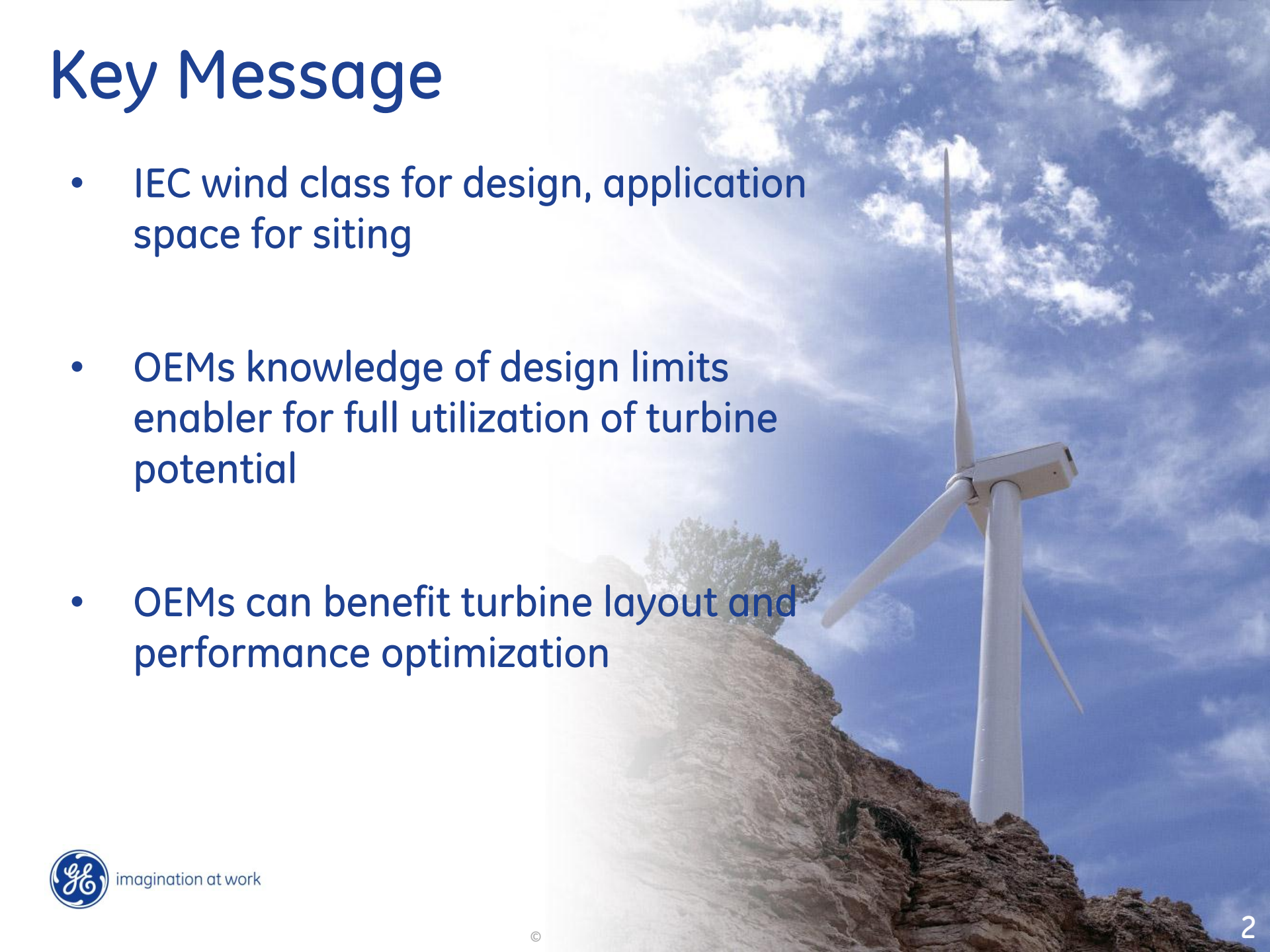
Key Message

- IEC wind class for design, application space for siting
- OEMs knowledge of design limits enabler for full utilization of turbine potential
- OEMs can benefit turbine layout and performance optimization



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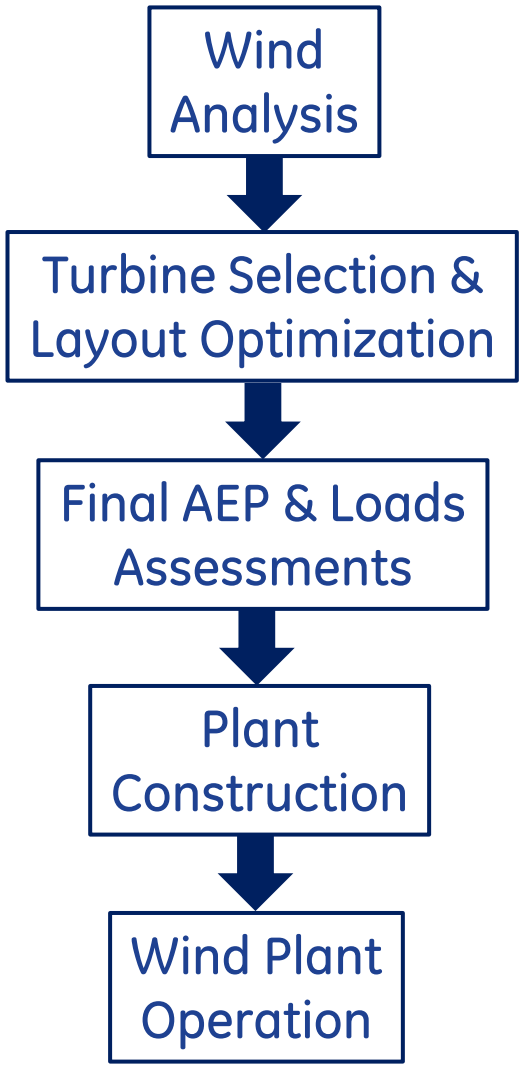
OEM Engagement



Customer typically has options

Customer typically has options
Can benefit from OEM detail design knowledge

Turbine suitability analysis and power curves for AEP

Turbine installation or turn key

O&M
Can benefit from OEM detail design knowledge

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AEP Annual energy production

Turbine Selection – IEC Wind Classes

Parameter	Label	IEC Example	Site Example	Site vs. IEC
Reference wind speed [m/s]	Vref	37.5	32	<
Average wind speed [m/s]	Vavg	7.5	8	>
Turbulence intensity at 15 m/s [%]	TI15	16%	12%	<
Air density [kg/m^3]	ρ	1.225	1.16	<
Wind shear exponent [-]	α	0.2	0.23	>
Flow inclination angle [deg.]	θ	8	4	<
Weibull shape parameter [-]	k	2	2.4	>

All site conditions < design → suitable but optimum?
All site conditions > design → not suitable
Otherwise (most common) → can't conclude

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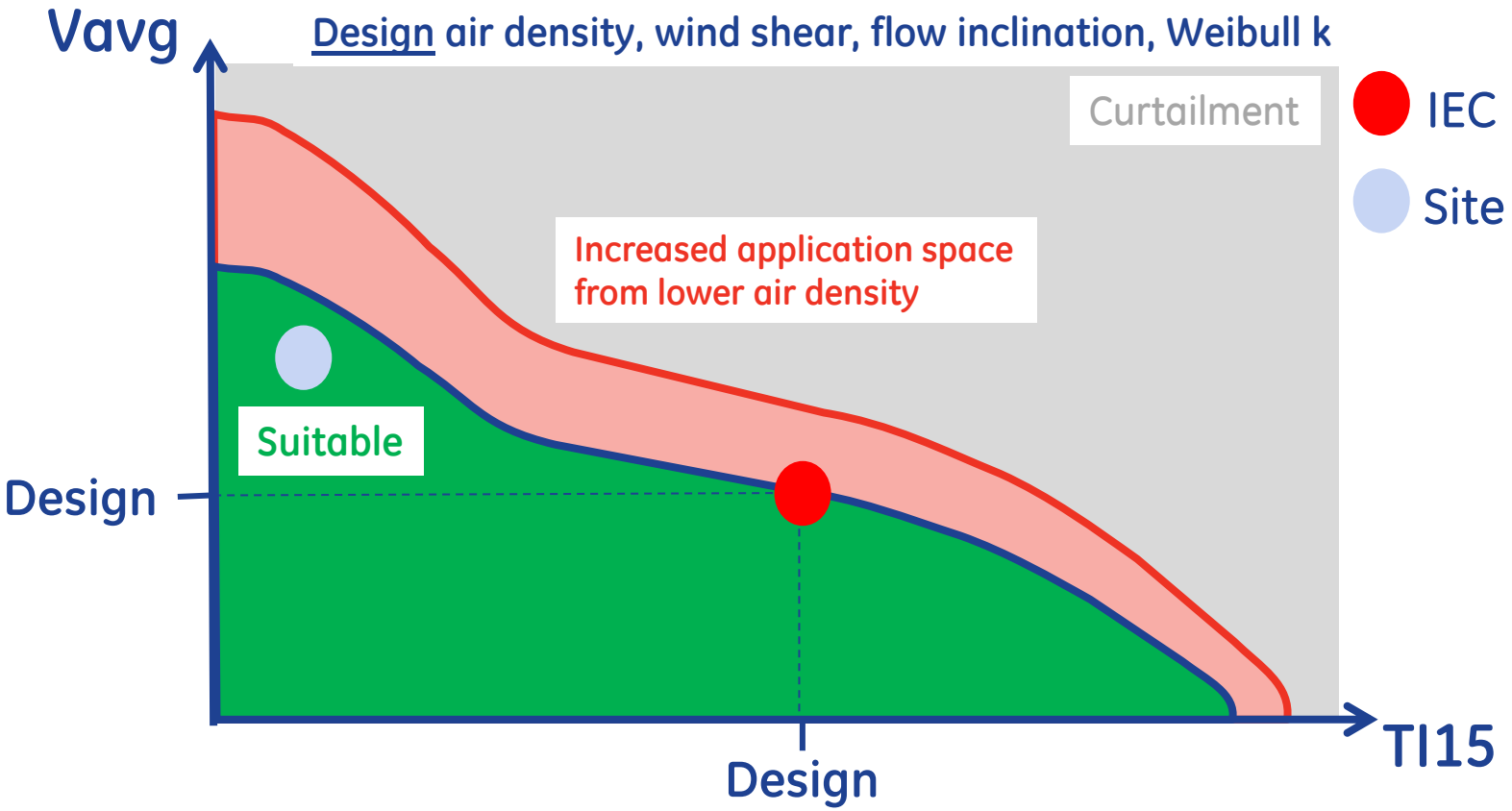
Turbine Selection – Application Space

Example – Fatigue Loads



Turbine application space is best for siting

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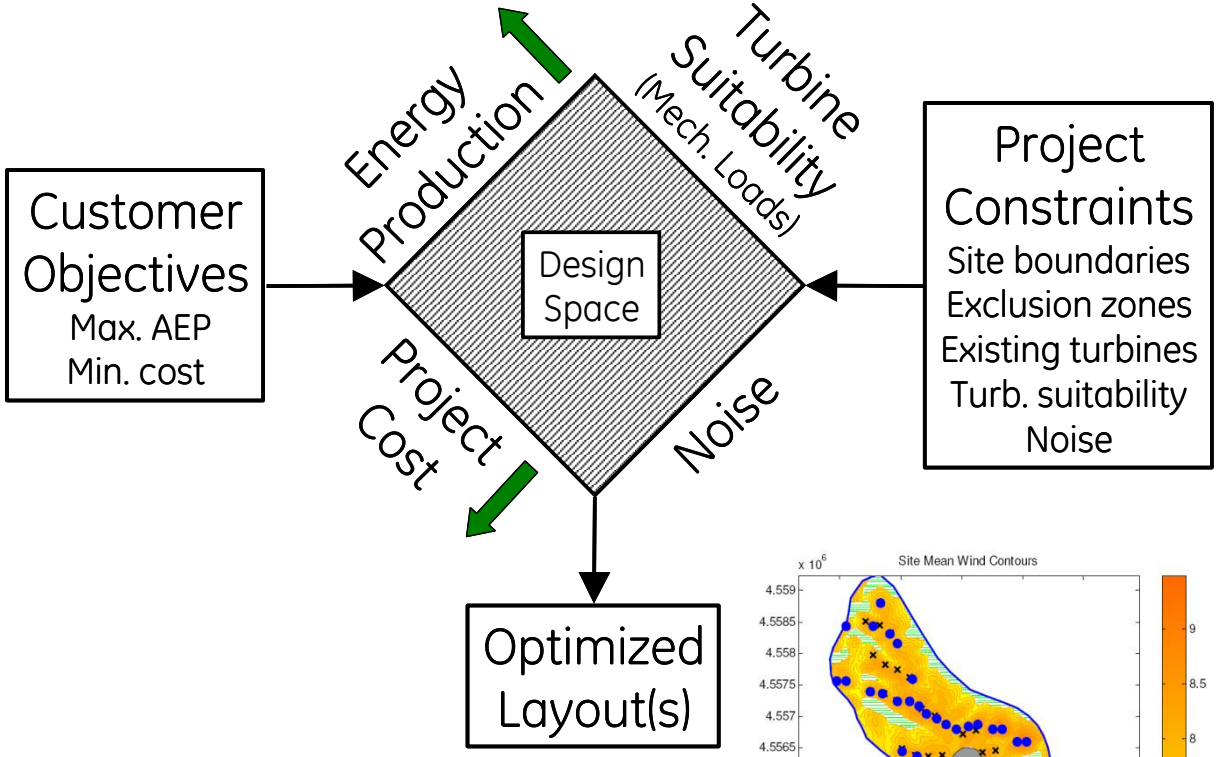
Layout Optimization - Method

- Multi-objectives, multi-constraints problem
- Loads analysis in optimization loop



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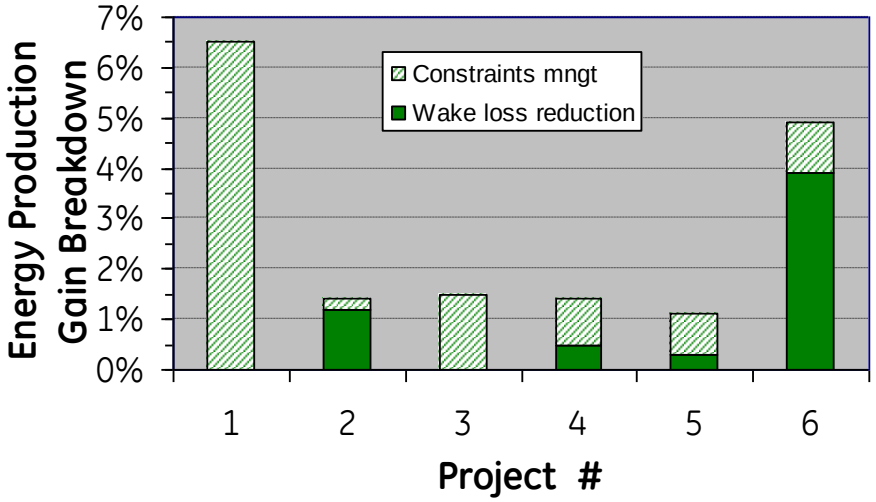
Ref.: 2009 EWEA Conf. Poster entitled "Turbine Layout Optimization - A Manufacturer's Perspective"

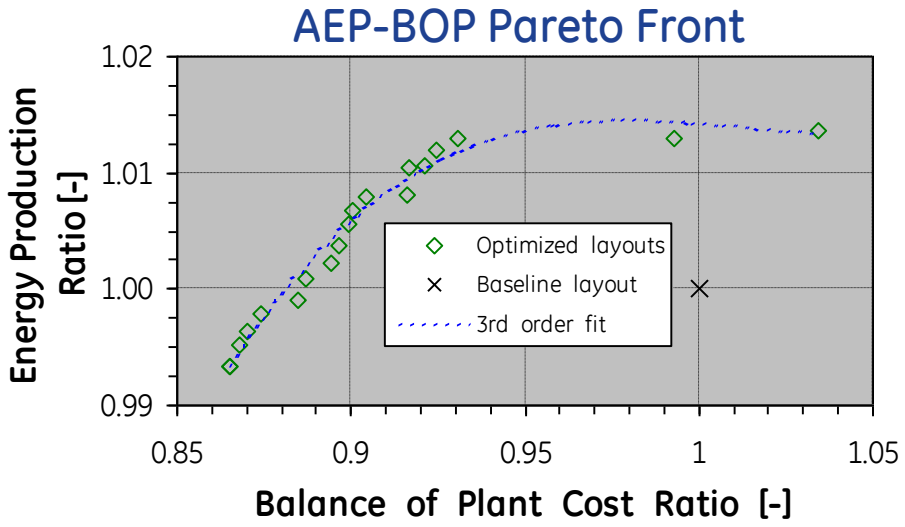
Layout Optimization – Sample Results

- 6 projects

Project #	# Turbines
1	41
2	80
3	166
4	32
5	160
6	75

- Site conditions and baseline layout from customer
- Turbine loads within design limits
- Average AEP gain of 2.8%
- Multi-objective optimization AEP-BOP Pareto front





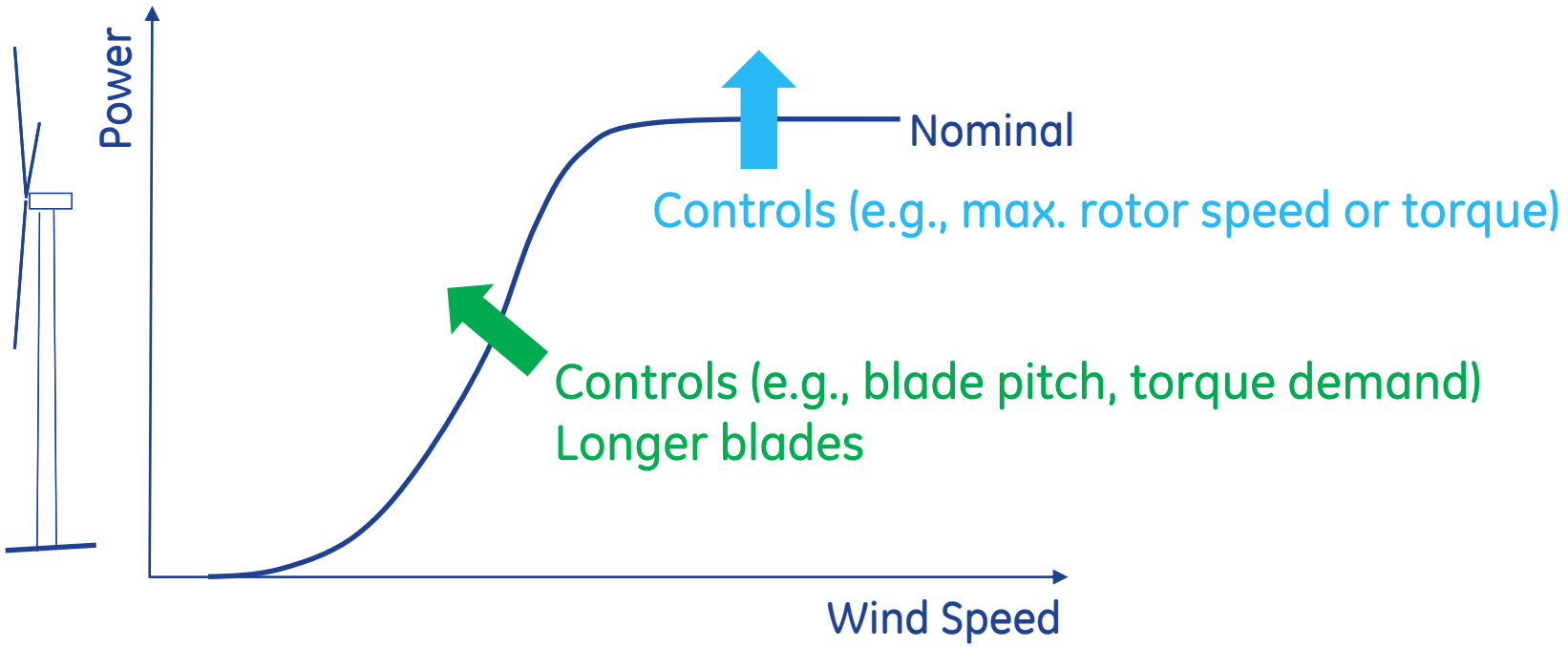
BOP Balance of plant

Ref.: 2009 EWEA Conf. Poster entitled "Turbine Layout Optimization - A Manufacturer's Perspective"

Turbine Performance Optimization

OEMs can "move" the power curve within design limits

- Address performance variations
- Take advantage of design margins
- Compensate for winds << predicted



Loads & controls modeling are enablers

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Challenges

Pre-construction

- Wind resource assessment preferences vary, no standard
- Wake modeling preferences vary & accuracy
- Balance of plant cost modeling
- Due diligence of OEM loads

Post-construction

- Post-warranty turbine data access
- Nacelle wind speed accuracy (absolute)
- Turbine wakes impacting met mast measurements
- Due diligence of turbine upgrade

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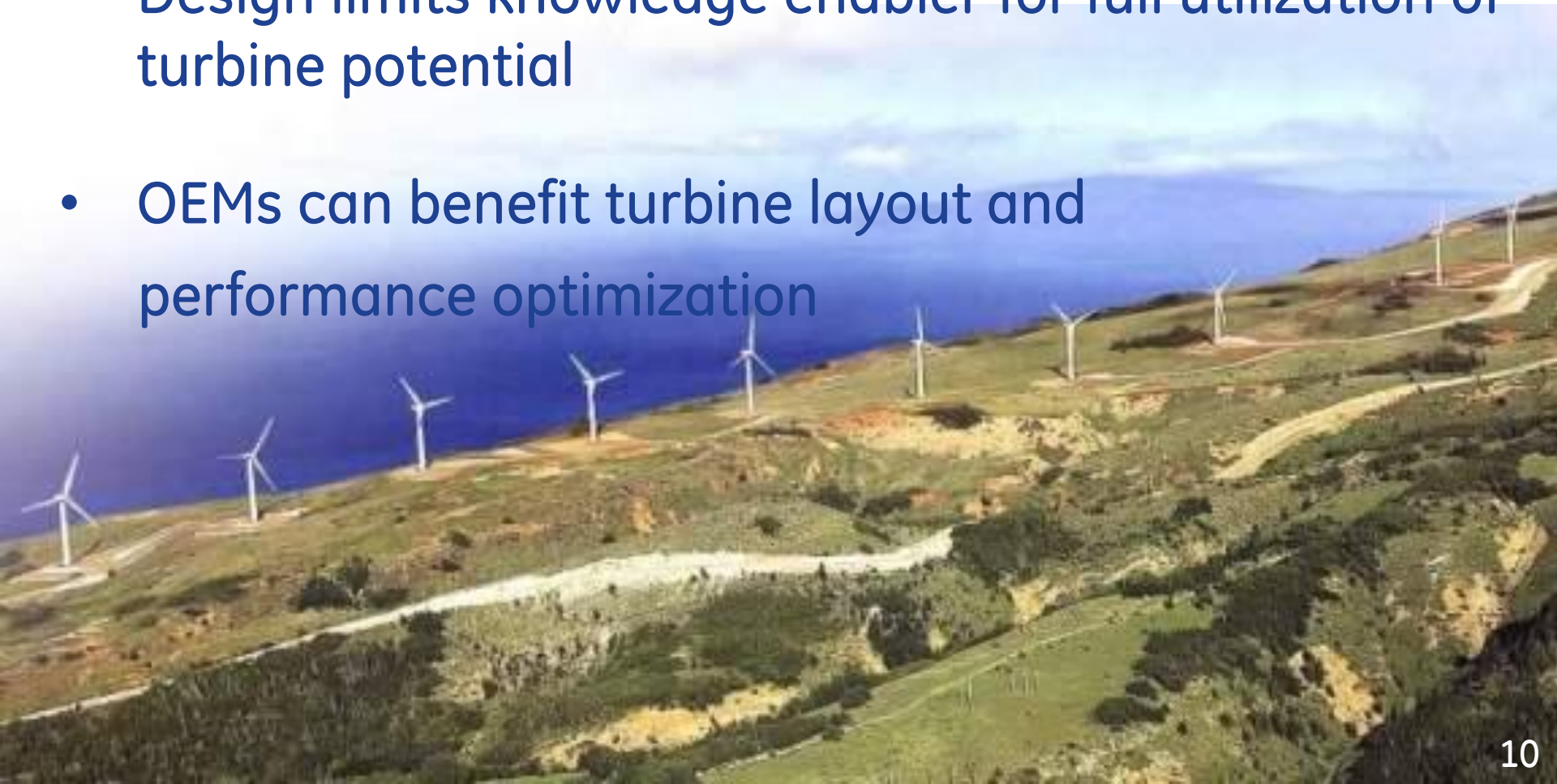
Conclusions

- Site turbines per application space
- Design limits knowledge enabler for full utilization of turbine potential
- OEMs can benefit turbine layout and performance optimization

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